REMARKS

Claims 17-22, 40 and 43 have been amended. Claim 17 has been amended to recite "bonded to a support member with said material" as supported on page 31, lines 8-24, of the instant specification. Claim 40 has been amended to recite "4,4'-diaminodiphenyl ether" as supported on page 14, line 21 of the specification. Claim 43 has been amended to correct a minor typographical error. Claims 17-22 have been amended to recite "under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2" and the upper temperature limit of 230°C is supported in the specification in the examples on page 23, lines 1-2 and page 26, lines 3-4. Applicants believe that the present amendment adds no new matter to the application.

Applicants believe that the amendment to claim 40 obviates the objection under 35 U.S.C. 132 and renders claim 40 in compliance with 35 U.S.C. 112.

In view of the amendment and for the following reasons, Applicants respectfully request that the present application be reconsidered and the claims allowed.

The Invention

The present invention pertains broadly to a material for a semiconductor device having a support member such as a lead frame to which a semiconductor die or chip is attached using the die-bonding material and encapsulated with resin. More particularly, one preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having a peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher when a semiconductor has been bonded to a support member with the material under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2.

In a second preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having the property of bonding a semiconductor chip to a support material under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2, and having a saturation moisture absorption of 1.0% by volume or less.

In a third preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having the property of bonding a semiconductor chip to a support material under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2, and having a modulus of elasticity of 10 MPa or less at a temperature of 250°C.

In a fourth preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having the property of bonding a semiconductor chip to a support material under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2, having a void volume of 10% or less in terms of voids present in the material and at an interface between the material and a support member at a stage where a semiconductor has been bonded to a support member by the material.

In a fifth preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having the property of bonding a semiconductor chip to a support material under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2, having a residual volatile component in an amount of not more than 3.0% by weight.

In a sixth preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having the property of bonding a semiconductor chip to a support material under conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2, having a water absorption of 1.5% by volume or less.

In a seventh preferred embodiment in accordance with the invention is a material characterized by an organic die-bonding film having the property of bonding a semiconductor chip to a support material under conditions of 100-250°C temperature and pressure of 0.1-30 gf/mm^2, and having a water absorption of 1.5% by volume or less, a saturation moisture absorption of 1.0% by volume or less, a modulus of elasticity of 10 MPa or less at a temperature of 250°C, a void volume of 10% or less in terms of voids present in the material and at an interface between the material and a support member at a stage where a semiconductor has been bonded to a support member by the material, a peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher when a semiconductor has been bonded to a support member with the material under conditions of 100-250°C temperature and pressure of 0.1-30 gf/mm^2, and a residual volatile component in an amount of not more than 3.0% by weight.

All of the remaining dependent claims recite various other preferred embodiments. The advantages of the preferred embodiments of the material in accordance with the present invention is that the material allows for the manufacture of semiconductor devices that have fewer flow cracks and other defects that devices made with silver paste have because the material of the present invention is less prone to forming reflow cracks during the fabrication semiconductor device process. Thus, the devices made with the material in accordance with the present invention can be reliably manufactured to have good durability that is an improvement over the prior art devices.

The Rejections

Claim 40 stands rejected under 35 U.S.C. 112, first paragraph, and objected to under 35 U.S.C. 132 for containing new matter. Claims 18, 19, 21 and 22 stand rejected under 35 U.S.C.

102(b) as anticipated by Morita (U.S. Patent 5,406,124). Claims 17, 23-27, 31, 33, 35, 37, and 42-50 stand rejected under 35 U.S.C. 103(a) as unpatentable over Morita. Claims 20, 28, 29, 30, 32, 34, 36, and 38 stand rejected under 35 U.S.C. 103(a) as unpatentable over Morita in view of Hozoji (Japanese document JP 5-218107). Claim 39 stands rejected under 35 U.S.C. 103(a) as unpatentable over Morita in view of Jackson (U.S. Patent 4,965,331). Claim 40 stands rejected under 35 U.S.C. 103(a) as unpatentable over Morita in view of Kunimune (U.S. Patent 4,656,238). Claim 41 stands rejected under 35 U.S.C. 103(a) as unpatentable over Morita in view of Baumann (U.S. Patent 5,296,567).

Applicants traverse the rejection for the foregoing reasons.

Applicants' Arguments

Claim 40 as amended complies with 35 U.S.C. 112 and does not contain any new matter.

The Morita reference discloses an "insulating adhesive tape" that includes a base supporting film and an adhesive layer formed on at least one surface thereof (see Abstract). The adhesive layer is a thermoplastic polymer comprising a thermoplastic polyimide, wherein the polymer has a glass transition temperature ranging from 180°C to 280°C and an elastic modulus ranging from 10^{10} dyne/cm^2 to 10^{11} dyne/cm^2 at 25°C, wherein the elastic modulus includes a value ranging from 10^2 dyne/cm^2 to 10^9 dyne/cm^2 at a temperature between 250°C and 300°C. The Morita reference discloses that the thermoplastic polymer has a water absorbing ratio of less than 1.2% (col. 9, lines 14-16); however, Morita does not explicitly state to what the percentage is relative. Specifically, the Morita reference only describes **% by weight** (col. 9, lines 35-39 and lines 53-55); therefore, it is suggested that Morita describes that the water absorbing ratio is less than 1.2% by weight. **There is nothing in the Morita et al. reference to teach, or even**

suggest, that the water absorption is 1.5% by volume or less as required by claims 22, 24, 28 and 30.

The Morita reference also discloses that the adhesive temperature for bonding IC chips to lead frames using the adhesive tape is selected from the range of 250-450°C (preferably 270-400°C) and the adhesive pressure is 1-50 kg/cm^2 (preferably 5-30 kg/cm^2), (col. 14, lines 3-14). However, the present invention has the advantage that die bonding can be carried out at significantly lower temperatures and pressures than the prior art. The present claims recite "conditions of 100-**230°C** temperature and pressure of 0.1-30 gf/mm^2" in independent claims 17-22. As the Morita et al. reference does not teach, or even suggest, a bonding temperature of less than 250°C, Morita et al. can not anticipate or make obvious the recited temperature range 100-230°C in combination with a pressure of 0.1-30 gf/mm^2.

Furthermore, Applicants point out that the Examiner admits that the Morita reference does not disclose a "17 degree peel strength of 0.5 Kgf/5mm x 5mm chip or above" (Office Action, dated September 10, 2001, page 9, lines 11-15), but the Examiner asserts that in the absence of unexpected results that such an increase in peel strength would be "ascertainable by routine experimentation and optimization" (Office Action, dated December 19, 2001, page 8, line to page 9, line 5); however, the Examiner does concede that "a disclosure that the limitations...produce an unexpected result, or are otherwise critical" would rebut any established *prima facie* case of obviousness. Applicants provide more than sufficient evidence of unexpected results as described below.

Applicants submit for the Examiner a Declaration by Takashi Masuko (hereafter the "Masuko Declaration"), dated March 5, 2002, attached herewith and filed in accordance with 37 C.F.R. 1.132. The Masuko Declaration establishes that when the novel film (see Section 7 on

page 3) in accordance with the present invention is compared to the prior art film (see Section 6 on page 3) disclosed by Morita et al. under identical experimental conditions, the result is that the novel film of the present invention demonstrates an "unexpected invulnerability" (page 7, lines 4-8). As shown in Table 2, when evaluating the two films for the occurrence of reflow cracks it was shown that while **all** of the Morita film samples under the given die-bonding conditions manifested reflow cracks, **none** of the samples made in accordance with the present invention had reflow cracks. In addition, when peel strength was measured (Matsuko Declaration, section 8) the peel strength was significantly greater for the novel film of the present invention over the Morita film (see Table 1). In fact, when the die-bonding condition was set as "250°C x 30gf/mm^2 x 20 sec," all of the chips made using the novel film were destroyed during testing because the bond strength was stronger than the chip. In other words, the bond strength of the material in accordance with the present invention was stronger than what this particular test could measure! Clearly, this is another superior and unexpected result.

In view of the Masuko Declaration, the *prima facie* case of obviousness standing against claims 17, 29 and 30-50 has been sufficiently rebutted to be overcome because of the superior and unexpected result of the material having "a peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher" as recited in these claims.

Thus, the Morita et al. reference can not anticipate, or render obvious, the subject matter of claims 18, 26 and 28-30, because Morita et al. does not teach, or even suggest, as admitted by the Examiner (Office Action dated December 19, 2002, page 13, lines 13-16) the **saturation moisture absorption of 1.0% by volume or less** recited in claims 18, 26 and 28-30.

Claim 30 recites bonding "conditions of 100-250°C temperature and pressure of 0.1-30 gf/mm^2;" however, the Morita et al. reference does not teach this particular combination of

bonding conditions and "peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher," "water absorbing ratio is 1.5% by volume or less," and "water absorbing ratio is 1.5% by volume or less" as recited in claim 30.

Moreover, even if a *prima* facie case of obviousness could be inferred from the teachings of Morita (which it can not) it is plainly shown that the present invention provides superior and unexpected improvements in both peel strength and reflow crack development over the Morita et al. adhesive tape. Specifically, the peel strength of the novel film in accordance with the present invention is consistently and significantly stronger than the peel strength of the Morita et al. film, and in some cases the peel strength of the instant novel film was so strong that it could not be fully measured using the disclosed techniques. In addition, the novel film in accordance with the present invention was "unexpectedly invulnerable" to the formation of reflow cracks, whereas 100% of the Morita films developed reflow cracks.

Hozoji discloses a "resin-sealed semiconductor device" wherein a die pad and a semiconductor element are fixed by using an adhesive layer in which a base material having a low moisture absorption rate (i.e. glass cloth or metal foil) is impregnated or coated with a bisphenol type epoxy resin, wire bonded, and with resin containing one or more of epoxy, phenol or polyimide resins (see Abstract). In addition, Hozoji teaches several desired low water absorption rates being changes in weight over a period of time (see paragraph [0016] and Table 1). Hozoji does not teach that **the saturation moisture absorption is 1.0% by volume or less** as recited in claims 18, 26, and 28-30.

The Hozoji reference adds nothing beyond the teachings of the Morita reference and it is silent with respect to the property of peel strength. Consequently, there is no proper motivation

to combine the references because the combination of references fails to disclose the "saturation moisture absorption of 1.0% by volume or less" recited in claims 18, 26, and 28-30.

The Jackson reference discloses "curable resin compositions," the Kunimune et al. reference discloses "soluble polyimide-siloxane precursor, process for producing same, and cross-linked polyimide-siloxane," and the Baumann et al. reference discloses "thermocurable compositions;" however, each of these references is silent with respect to the claimed characteristics of peel strength recited in claims 17, 29 and 30, and claimed saturation moisture absorption recited in claims 18, 26 and 28-30. Furthermore, neither the Jackson reference, the Kunimune et al. reference, nor the Baumann et al. reference disclose the claimed bonding "conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2" recited in claims 17-22.

Conclusion

The rejection of claims 17-22 and 30 under 35 U.S.C. 103(a) over the Morita reference is untenable because all of the claimed limitations are neither disclosed nor suggested by the reference. Specifically, Morita does not teach or suggest: (a) the bonding "conditions of 100-230°C temperature and pressure of 0.1-30 gf/mm^2" recited in claims 17-22; (b) "peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher" recited in claim 17, 29 and 30; or (c) "saturation moisture absorption of 1.0% by volume or less" recited in claims 18, 26, and 28-30. Applicants have shown that none of the Hozoji reference, the Jackson reference, the Kunimune et al. reference, and the Baumann et al. reference makes up these deficiencies in the Morita reference.

Furthermore, Applicant has shown that the material in accordance with the present invention manifests superior and unexpected results, including a peel strength markedly

improved over the material disclosed by the prior art as supported by the attached Matsuko Declaration, which sufficiently rebuts any potential *prima facie* case of obviousness.

For all of the above reasons, claims 17-50 are in condition for allowance, and prompt notice of allowance is earnestly solicited. Questions are welcomed by the below-signed attorney for applicants.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

17. (Amended) A material comprising an organic die-bonding film having a peel strength of 0.5 kgf/(5 mm x 5 mm chip) or higher when a semiconductor has been bonded to a support member with said material under conditions of 100-23~~5~~0°C temperature and pressure of 0.1-30 gf/mm^2.

18. (Amended) A material comprising an organic die-bonding film having the property of bonding a semiconductor chip to a support member under conditions of 100-23~~5~~0°C temperature and pressure of 0.1-30 gf/mm^2, and having a saturation moisture absorption of 1.0% by volume or less.

19. (Amended) A material comprising an organic die-bonding film having the property of bonding a semiconductor chip to a support member under conditions of 100-23~~5~~0°C temperature and pressure of 0.1-30 gf/mm^2, and having a modulus of elasticity of 10 MPa or less at a temperature of 250°C.

20. (Amended) A material comprising an organic die-bonding film having the property of bonding a semiconductor chip to a support member under conditions of 100-23~~5~~0°C temperature and pressure of 0.1-30 gf/mm^2, and having a void volume of 10% or less in terms of voids present in the material and at an interface between the~~said~~ material and a support member at a stage where a semiconductor has been bonded to a support member by the~~said~~ material.

21. (Amended) A material comprising an organic die-bonding film having the property of bonding a semiconductor chip to a support member under conditions of 100-23~~5~~0°C temperature and pressure of 0.1-30 gf/mm^2, having a residual volatile component in an amount of not more than 3.0% by weight.

22. (Amended) A material comprising an organic die-bonding film having the property of bonding a semiconductor chip to a support member under conditions of 100-23~~5~~0°C temperature and pressure of 0.1-30 gf/mm^2, having water absorption of 1.5% by volume or less.

40. (Amended) A material according to claim 17, wherein said material is an organic material comprising a polyimide synthesized from 1,2-(ethylene)bis(trimellitate anhydride) and 4,4'-diaminodiphenyl ether.

43. (Amended) A material according to claim 17, wherein said material is an organic material comprising a polyimide synthesized from 1,2-(ethylene)bis(trimellitate anhydride), 1,10-(decamethylene)bis(trimellitate anhydride), and 2,2-bis[4-(4-aminophenoxy)phenyl] propane.